M02/420/H(2)

CHEMISTRY
HIGHER LEVEL
PAPER 2

Monday 20 May 2002 (afternoon)

2 hours 15 minutes

Name

Number

INSTRUCTIONS TO CANDIDATES

- Write your candidate name and number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: Answer all of Section A in the spaces provided.
- Section B: Answer two questions from Section B. Write your answers in a continuation answer booklet, and indicate the number of booklets used in the box below. Write your name and candidate number on the front cover of the continuation answer booklets, and attach them to this question paper using the tag provided.
- At the end of the examination, indicate the numbers of the Section B questions answered in the boxes below.

QUESTIONS ANSWERED		EXAMINER	TEAM LEADER	IBCA
SECTION A	ALL	/40	/40	/40
SECTION B QUESTION QUESTION		 /25 /25	 /25 /25	 /25 /25
NUMBER OF CONTINUATION BOOKLETS USED	. . . .	TOTAL /90	TOTAL /90	TOTAL /90

SECTION A

*Candidates must answer **all** questions in the spaces provided.*

In order to receive full credit in Section A, the method used and the steps involved in arriving at your answer must be shown clearly. It is possible to receive partial credit but, without your supporting work, you may receive little credit. For numerical calculations, you are expected to pay proper attention to significant figures.

1. The following data were obtained for the reaction between gases **A** and **B**:

Experiment	**Initial concentration of reactants / mol dm^{-3}**		**Initial rate of reaction / mol dm^{-3} min^{-1}**
	A	**B**	
1	1.0×10^{-3}	2.0×10^{-3}	3.0×10^{-4}
2	2.0×10^{-3}	2.0×10^{-3}	3.0×10^{-4}
3	1.0×10^{-3}	4.0×10^{-3}	1.2×10^{-3}

(a) Define the term *overall order of reaction*. *[2]*

. . . .

. . . .

(b) Deduce the order of reaction with respect to **A** and the order of reaction with respect to **B**. *[2]*

. . . .

. . . .

. . . .

(c) Write the rate expression for the reaction between **A** and **B**. *[1]*

. . . .

(d) Use the data from Experiment 1 to calculate the value of the rate constant for the reaction and state its units. *[2]*

. . . .

. . . .

. . . .

(e) The reaction between gases **A** and **B** is repeated at a pressure double that of the original. Determine how many times faster the reaction will be when the pressure is doubled. *[1]*

. . . .

(This question continues on the following page)

(Question 1 continued)

(f) Some solids act as *heterogeneous* catalysts in this reaction. State what is meant by the term *heterogeneous* and outline how such catalysts work. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

(g) State and explain how the following changes affect the rate of reaction between **A** and **B**:

(i) Using a catalyst *[2]*

. . . .

. . . .

. . . .

(ii) Decreasing the temperature *[2]*

. . . .

. . . .

. . . .

2. The existence of isotopes in magnesium can be shown using a mass spectrometer. The operation of a mass spectrometer can be described in terms of five main stages. The first is evaporation and the last is detection.

(a) After evaporation, the magnesium is then ionised. Outline how it is ionised. *[2]*

(b) State the names, in the correct order, of the other two stages, and in **each** case state the technique used. *[4]*

(c) The relative abundances of the three isotopes of magnesium are as follows:

$$^{24}\mathrm{Mg}\ \square\ 78.6\,\%,\ ^{25}\mathrm{Mg}\ \square\ 10.1\,\%,\ ^{26}\mathrm{Mg}\ \square\ 11.3\,\%.$$

Calculate the relative atomic mass of magnesium using these values, giving your answer to three decimal places. *[2]*

(d) Write the electronic configuration of magnesium using the spdf notation. *[1]*

3. In aqueous solution, hydrochloric acid is a strong acid and ethanoic acid is a weak acid.

(a) Use the Brønsted–Lowry theory to state why **both** substances are classified as acids. *[1]*

(b) Solutions of 0.1 mol dm^{-3} hydrochloric acid and 0.1 mol dm^{-3} ethanoic acid have different electrical conductivities.

(i) State and explain which solution has the greater conductivity. *[1]*

(ii) Calculate the pH value of 0.1 mol dm^{-3} hydrochloric acid, and suggest a value for the pH of 0.1 mol dm^{-3} ethanoic acid. *[2]*

(c) Write an equation to show the reaction of ethanoic acid with water and classify **each** product as a Brønsted–Lowry acid or base. *[2]*

(d) Use information from Table 16 of the Data Booklet to calculate the value of the ionisation constant, K_a, of ethanoic acid. *[1]*

(e) Write the expression for the ionisation constant, K_a, of ethanoic acid. *[1]*

(This question continues on the following page)

(Question 3 continued)

(f) Use your answers to (d) and (e) to calculate the pH value of a 0.050 mol dm^{-3} solution of ethanoic acid. *[2]*

. . . .

. . . .

. . . .

. . . .

4. A student is asked to prepare some copper(II) nitrate by reacting nitric acid with copper(II) oxide.

(a) Write a balanced equation for this reaction. *[1]*

. . . .

. . . .

(b) The student carries out this reaction by adding 0.0345 mol of copper(II) oxide to 36.0 cm^3 of 1.15 mol dm^{-3} nitric acid solution. Calculate the amount (in mol) of nitric acid. *[1]*

. . . .

. . . .

(c) Use the information in (a) and (b) to identify the limiting reagent and determine the amount (in mol) of copper(II) nitrate formed. *[2]*

. . . .

. . . .

. . . .

. . . .

. . . .

(d) The product of this reaction is isolated as copper(II) nitrate trihydrate. Calculate the molar mass of copper(II) nitrate trihydrate and the mass of product obtained. *[2]*

. . . .

. . . .

. . . .

. . . .

SECTION B

*Answer **two** questions. Write your answers in a continuation answer booklet. Write your name and candidate number on the front cover of the continuation answer booklets, and attach them to this question paper using the tag provided.*

5. This question is about four compounds **A**, **B**, **C** and **D**. **B**, **C** and **D** can be made from **A** by the following reactions. **A**, **B** and **C** are liquid at room temperature, and each compound's molecular formula is shown.

$$\underset{\mathbf{D}}{C_4H_8} \longleftarrow \underset{\mathbf{A}}{C_4H_{10}O} \longrightarrow \underset{\mathbf{B}}{C_4H_8O} \longrightarrow \underset{\mathbf{C}}{C_4H_8O_2}$$

Sodium was added to each liquid compound. Gas bubbles formed slowly in **A** but rapidly in **C**. The infrared spectra of the compounds showed characteristic absorptions at the following wavenumbers (cm^{-1}) :

A: 3400
B: 1720
C: 1720 and 3100
D: 1650

(a) Explain, by referring to the Data Booklet, how the infrared absorptions listed above can be used to identify the functional groups present in **each** of the compounds **A**, **B**, **C** and **D**. *[4]*

(b) Use the information above to identify **each** of the compounds **A**, **B**, **C** and **D**, giving the name **and** structural formula of each one. *[4]*

(c) (i) State the type of reaction occurring when **A** is converted to **B** and **C**, and state a suitable reagent and conditions for the reaction. *[3]*

(ii) Explain why **B** is much harder to obtain than **C** in this reaction. *[1]*

(d) State the type of reaction occurring when **A** is converted to **D**, and name a catalyst that is used. What other product is formed as well as **D**? *[3]*

(e) Identify the gas formed when **A** and **C** react with sodium and write an equation for **each** of the reactions occurring. Name the other product of the reaction between sodium and **C**. *[4]*

(f) Arrange the compounds **A**, **B** and **C** in **increasing** order of boiling point (lowest boiling point first). Explain your choice. *[4]*

(g) None of the compounds **A**, **B**, **C** and **D** exist as optical isomers. State the structural feature which is present in a compound that exists as optical isomers. Draw the structural formula of the isomer of **A** that exists as optical isomers. *[2]*

6. (a) The electrolysis of sodium chloride can be carried out with the sodium chloride in the molten state or as a concentrated solution in water.

(i) Sketch a diagram showing how molten sodium chloride could be electrolysed in a beaker. Show clearly the polarity of the electrodes, the direction of the electron flow in the connecting wires and the products at **each** electrode. Write equations to show the formation of the product at **each** electrode. *[5]*

(ii) When aqueous sodium chloride solution is electrolysed, the product at one of the electrodes is different. Name this product and explain why it is formed instead of the product in (i). *[3]*

(iii) In the electrolysis of molten sodium chloride, a current of 5 A is passed for 1 hour. Calculate the mass of the product formed at the negative electrode. *[3]*

(b) Ethanedioate ions, $C_2O_4^{2-}$, can be oxidised to carbon dioxide by acidified dichromate(VI) ions.

(i) Deduce the half-equation for the oxidation of ethanedioate ions. Deduce the oxidation number of carbon in ethanedioate ions and in carbon dioxide, and use your values to explain why carbon is oxidised in this reaction. *[4]*

(ii) Using information from the Data Booklet, write the equation for the reaction between ethanedioate ions and dichromate(VI) ions in acid solution. *[2]*

(c) An electrochemical cell is constructed from two half-cells connected by a high-resistance voltmeter. One half-cell contains nickel in a solution of nickel nitrate, and the other contains silver in silver nitrate solution.

(i) State the conditions which must apply to the solutions for the measurements made to be described as *standard*. *[2]*

(ii) Outline how the two half-cells must be connected before any voltage readings can be made. *[2]*

(iii) Assuming that standard conditions apply, calculate the cell potential using information from the Data Booklet. Write the shorthand notation for the cell, including state symbols, and give the equation for the reaction occurring in the cell. *[4]*

7. (a) The elements in group 1 show a number of trends in their physical and chemical properties, some of which can be seen using information in the Data Booklet.

(i) Explain the trends in both ionisation energy and melting point from lithium to caesium. *[4]*

(ii) Write the equation for the reaction that occurs when a small piece of lithium is added to water, and describe **two** observations you could make during the reaction. State what additional **observation** could be made if potassium were used instead of lithium. *[4]*

(iii) State and explain the trend in reactivity towards water shown by the elements lithium, sodium and potassium. *[3]*

(b) The elements of period 3 and their compounds show periodic trends. By referring to the type of bonding and structure, where appropriate, explain the following:

(i) The melting point of magnesium is greater than that of sodium. *[3]*

(ii) Silicon has the highest melting point in the period. *[2]*

(iii) Phosphorus, chlorine and argon have lower melting points than the other elements in the period. *[2]*

(iv) Sulfur has a higher melting point than phosphorus. *[1]*

(c) Complex ions are a feature of the chemistry of d-block elements. For each of the following reactions give the formula of the complex ion formed and deduce its shape.

(i) Some iron metal is dissolved in sulfuric acid and left exposed to air until a yellow solution is formed. *[2]*

(ii) A solution containing copper(II) ions is added to concentrated hydrochloric acid, forming a yellow solution. *[2]*

(iii) A small amount of sodium hydroxide solution is added to silver nitrate solution. Ammonia solution is added until a colourless solution is obtained. *[2]*

8. (a) The types of bonding and structure in elements and compounds can be used to explain a variety of physical properties. Use your knowledge of bonding and structure to answer each of the following:

(i) Explain why carbon (diamond) is a very hard substance and does not conduct electricity but carbon (graphite) is very soft and is a good conductor. *[6]*

(ii) Describe the bonding within and between the molecules in liquid fluorine. *[2]*

(iii) Explain why lithium fluoride does not conduct electricity until it is heated above its melting point. *[2]*

(b) Draw and name the shape of each of the following:

(i) XeF_4 *[2]*

(ii) NH_4^+ *[2]*

(iii) PCl_6^- *[2]*

(c) (i) Using ethane as your example, explain the terms *hybridisation* and *sigma bonding*, and state the type of hybridisation shown by the carbon atoms in ethane. *[5]*

(ii) Ethene and ethyne also contain pi (π) bonds. Explain how pi (π) bonding differs from sigma (+) bonding. State the type of hybridisation shown by the carbon atoms in **each** compound. *[4]*